

Planting date, irrigation, maturity group, year, and environment effects on *Phomopsis longicolla*, seed germination, and seed health rating of soybean in the early soybean production system of the midsouthern USA

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Abstract

Field studies were conducted in 1995–1997 and in 2001 in plots naturally infested with *Phomopsis* sp. at Stoneville, MS (33°26'N latitude) to determine the effects of irrigation, maturity group (MG), year and date of planting (DOP) on the incidence of *Phomopsis longicolla* (PL), seed germination, and seed health rating (SHR), a measure of diseased seed and germinated seedlings, in the early soybean [*Glycine max* (L.) Merr.] production system (ESPS). Except for only an irrigation effect on SHR, there was a significant effect due to year, irrigation, MG, and DOP on the incidence of *P. longicolla* and seed germination. There was a negative relationship between PL and seed germination in 1995 ($r = -0.77, P \leq 0.05$), 1996 ($r = -0.97, P \leq 0.05$) and 2001 ($r = -0.87, P \leq 0.05$). There was also a negative relationship between germination and SHR in 1996 ($r = -0.98, P \leq 0.05$), 1997 ($r = -0.86, P \leq 0.05$), and 2001 ($r = -0.99, P \leq 0.05$), but not in 1995. There was a positive relationship between PL and SHR for 1996 ($r = 0.97, P \leq 0.05$), 1997, and 2001 ($r = 0.87, P \leq 0.05$). Irrigated treatments in drier years (1995 and 1997) produced a higher level of PL than did nonirrigated treatments, suggesting that soil moisture could have increased the relative humidity in the canopy that provided favorable environment for PL. The incidence of PL was also associated with total rainfall and rainfall frequency for each year. It was higher in 1996 and 2001 than in 1995 and 1997. Germination was increased and PL and SHR were reduced in seed from drier years. The rainfall amount in August of 2001 and 1996 was 220 and 112 mm, and the number of rainy days in the same month was 14 and 11 days, respectively. Early planting of MG IV varieties resulted in higher level of PL and SHR and lower germination. Conducive moisture environment overrode the effects of irrigation. A significant difference between MG IV and V in 2001 was detected in SHR and germination than in PL. This indicates that SHR and germination may be used in concert when evaluating the effect of PL on seed quality. This research highlights the importance and significance of PL and its effect on SHR and seed germination. It also highlights that environmental conditions that are conducive are required to see significant treatment effects.

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Keywords: Soybean seed quality; *Phomopsis longicolla*; Seed health rating; Soybean seed germination; Early soybean production system plantings

1. Introduction

An early soybean production system (ESPS), in which early maturing indeterminate cultivars are planted from

late March through April, is being used by growers in the midsouthern USA (Heatherly, 1999a). One of the benefits of using early maturing cultivars in the ESPS is to avoid late-season drought. Traditional soybean production in the midsouthern USA typically involved planting in May or later, with the bulk of the acreage planted in MGs VI and VII cultivars in the early 1980's

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(Heatherly, 1999a). However, the bulk of acreage is now planted to MGs IV and V cultivars with planting as early as late March.

Quality of harvested seed has become a matter of concern when using the ESPS. Infection of soybean seed by PL, the principal cause for *Phomopsis* seed decay, has been implicated in poor seed quality associated with ESPS plantings in regions where the climate is warm and humid during and after seed maturation (Sinclair, 1999; Thomison et al., 1990; TeKrony et al., 1984, 1983). Higher levels (>30%) of *Phomopsis* seed infection resulted in lower (<85%) germination occurred for early and late plantings of early maturing cultivars (TeKrony et al., 1996).

Previous reports suggest that low seed quality commonly occurs when early maturing cultivars are grown in the ESPS (Mayhew and Caviness, 1994; TeKrony et al., 1984, 1980). The general conclusion is that planting late-maturing cultivars or delaying planting of early maturing cultivars reduces seed infection by shifting seed maturation to cooler, drier conditions that are less favorable for *Phomopsis* seed infection (Grau and Oplinger, 1981; TeKrony et al., 1984, 1980). In another report, planting soybean in April may not be practical on clay or other poorly drained soils since rain is generally more abundant in April than in May or June (Wrather et al., 1996).

The seed health of soybean has two aspects: the healthiness or freedom from seed-borne diseases of seeds to be planted, and maintenance of seed/seedling health after planting (Agrawal and Sinclair, 1987). The healthiness of seeds per se is an important but largely ignored attribute of seed quality. Heatherly (1999a, 1996) found that drought stress during seed development in nonirrigated early maturing cultivars produced inferior quality seed based on seed germination compared with seed from irrigated plots. He also determined (1996) that planting MG IV and V varieties in May (late planting) and irrigating will almost always ensure seed with highest germination percentage. However, the incidence of PL and SHR were not measured. The effect of planting early and late under extreme and normal environmental conditions over several years and its effect on PL, SHR, and germination have not been investigated. Since most of the early studies were conducted under rainfed environments, the combined effects of irrigation and rainfall over several years on the incidence of PL, SHR, and germination have not been compared and fully investigated. The objectives of this research were to: (1) assess data gathered in 1995–1997 and 2001 for the incidence of PL seed infections, germination, and SHR in MG IV and V cultivars in early and late plantings under irrigated and non-irrigated environments in the ESPS in the mid-south; and (2) establish a correlation between PL, SHR, and germination.

2. Material and methods

2.1. Experimental location and design

Field studies were conducted in 1995–1997 and in 2001 in plots naturally infested with *Phomopsis* spp. at Stoneville, MS. Soil at the experimental site was a Sharkey clay (very fine, smectitic, thermic, Chromic Epiaquect (NRCS, 1997), and all experiments were established in a stale (untilled in the spring) seedbed (Heatherly, 1999b; Heatherly et al., 1992) that had been tilled with a disk-harrow and/or a spring-tooth field cultivator in the fall. Treatments were arranged in a split-plot factorial, with DOP as the main plot and cultivar within MG IV and V as the sub-plot. Planting and harvesting dates as well as the number of cultivars used within each MG are listed in Table 1. Cultivars were selected based on regional variety trial results and use patterns by producers. A total of 10 cultivars from MG IV and 8 cultivars from MG V were used. Indeterminate MG IV and determinate MG V cultivars were used each year and cultivars were added or removed to reflect breeding progress. Since all the cultivars used in these experiments are known to be highly susceptible to PL, the effect of PL on individual cultivars is not reported in this experiment; rather, data are presented by MG. Seeds were treated with metalaxyl (*N*-(2, 6-dimethylphenyl)-*N*-(methoxyacetyl) alanine methyl ester) fungicide at 0.3 g ai kg⁻¹ seed prior to seeding. Row spacing was 50 cm and seeding rate was 130,000 seed ha⁻¹. Plots were 18 m long and 4 m (eight rows) wide. Glyphosate (*N*-(phosphonomethyl)glycine) was applied preplant in April of each year to control existing weeds. Pre-emergence and postemergence herbicides were broadcast-applied at labelled rates.

Irrigation was applied to designated plots by the furrow method using gated pipe. Irrigation was applied when soil water potential at the 30-cm depth decreased to about -70 kPa based on tensiometer readings (Heatherly, 1996; Heatherly and Spurlock, 1993). Irrigation regimes were not replicated; i.e. a full complement of planting dates and cultivars was grown in separate but adjacent nonirrigated and irrigated studies rather than in studies where irrigation treatments were randomized. An 18-m-long section of each of the centre four rows of each plot was harvested at maturity to determine seed quality and incidence of seed-borne, plant pathogenic fungi. Data on rainfall, relative humidity, and maximum and minimum temperatures were obtained from the Stoneville weather station (Boykin et al., 1995).

2.2. Assessment of seed health

Two methods were used for assessing seed health. The first method, a seed bioassay, was based on the recovery

Table 1

Number of soybean cultivars within MGs IV and V, dates of planting, and harvest dates for 1995–1997 and 2001 at Stoneville, MS

Year	Date of planting		MG: cultivars used	Date of R8 stage	Harvest date
1995	18 Apr	(Early)	IV: RA 452, DP 3478, HBK 4998, Pioneer 9501 V: DP 3589, Asgrow 5979, Pioneer 9592, Hutcheson	15 Sep 22 Sep	20 Sep 25 Sep
	9 May	(Late)	IV: RA 452, DP 3478, HBK 4998, Pioneer 9501 V: DP 3589, Asgrow 5979, Pioneer 9592, Hutcheson	22 Sep 29 Sep	28 Sep 2 Oct
1996	30 Apr	(Early)	IV: Dixie 478, DK 4875, DP 3478, Pioneer 9501, V: HY574, Asgrow 5979, DP 3588, Hutcheson	5 Sep 23 Sep	13, 19, 26 Sep 7 Oct.
	15 May	(Late)	IV: Dixie 478, DK 4875, DP 3478, Pioneer 9501, Asgrow 4701 V: HY574, Asgrow 5979, DP 3588, Hutcheson	12 Sep. 27 Sep.	26 Sep. Oct 1
1997	9 Apr	(Early)	IV: Dixie 478, Asgrow 4922, DP 3478, HBK 4998 V: HY574, Asgrow 5979, DP 3588, Hutcheson	1 Sep. 15 Sep.	5 Sep 22 Sep.
	12 May	(Late)	IV: Dixie 478, A 4922, DP 3478, HBK 4998 V: HY574, Asgrow 5979, DP 3588, Hutcheson	15 Sep 25 Sep	22 Sep 1 Oct.
2001	23 Mar	(Early)	IV: Asgrow 4702, AP 4882	10 Aug	13 Aug
	06 Apr		V: Asgrow 5701, Hutcheson	17 Aug	21 Sep
	20 Apr	(Late)	IV: Asgrow 4702, AP 4882	27 Aug	10 Sep
	01 May		V: Asgrow 5701, Hutcheson	26 Sep	26 Sep

of microorganisms on potato-dextrose agar (Difco Laboratories, Detroit, MI) acidified with 5% lactic acid (APDA). Samples of soybean seeds (500 g) from each plot were collected at harvest, dried under forced air at 32 °C so that seeds were of uniform moisture, and used to determine the percentage incidence of seed-borne microorganisms. One hundred seeds from each replication were plated on APDA and incubated for 7 days at 24 °C. The incidence of PL growing on the medium was identified based on morphological characteristics according to Hobbs et al. (1985) and recorded. The second method was to evaluate seed germination. For germination assessment, 100 seed from each field plot were placed on moistened wadded cellulose paper (kimpak) in a seed germinator (Lab-Line Instruments, Model Ambi-Hi-Lo-Chamber) at a constant temperature of 25 °C and 90% relative humidity for 7 days. The number of seeds germinated was then recorded. A seed was counted germinated when the radical was 2.5 times the length of the cotyledon.

In many cases, seeds that should be counted as germinated will have disease symptoms (seed health rating (SHR)). This will still be counted as germinated but they obviously need to be categorized in some fashion to indicate that they were unhealthy. Also, those seeds that have not germinated may also be diseased. In order to supplement the germination test, the following protocol was used to indicate the general health of a seed lot using SHR systems: (a) roots may be browned or withered at some point along the length of the root or at the root tip; (b) roots may have fungal mycelium growing on them; and (c) seeds that are ungerminated may have fungal mycelial growth. One hundred seed from each field plot were taken and germinated using the procedure described as above. The total number of seed or seedlings that were in categories a, b, and c was

recorded. The SHR (expressed in percentage) is based on the number of unhealthy seeds or seedlings, the higher the number, the more unhealthy the seed lot. The supplemental germination test was necessary to avoid the confounding effect of germinated seeds that were also diseased. The plating of seeds on media, germination, and the SHR tests were performed 7–10 days after harvest.

2.3. Data analysis

Data for the 4 years were analysed using SAS mixed model (1999) to determine the effect of DOP (early and late), MG (IV and V), year, and irrigation on the incidence of PL. The Pearson correlation coefficients were determined for PL, SHR, and germination using SAS Procedures Guide and Version (1999).

In this analysis, the fixed effect of experiment has a factorial structure of two DOPs (early and late) by two levels of irrigation (nonirrigated and irrigated). Mean separation was evaluated through a series of protected pair-wise contrasts among all treatments (Saxton, 1998). When a significant *F*-value ($P \leq 0.05$) indicated differences among treatments, Fishers least significant difference (LSD) was calculated to compare means among main and subunit effects and their interactions.

3. Results

Rainfall amount (220 mm) in August of 2001 was approximately twice, three times and ten times that of 1996 (112), 1997 (70), and 1995 (25), respectively (Fig. 1A). Thirty-year (1971–2000) average rain at Stoneville in August is 52 mm. In August of 2001, there were 14 days of rain and the minimum RH was greater

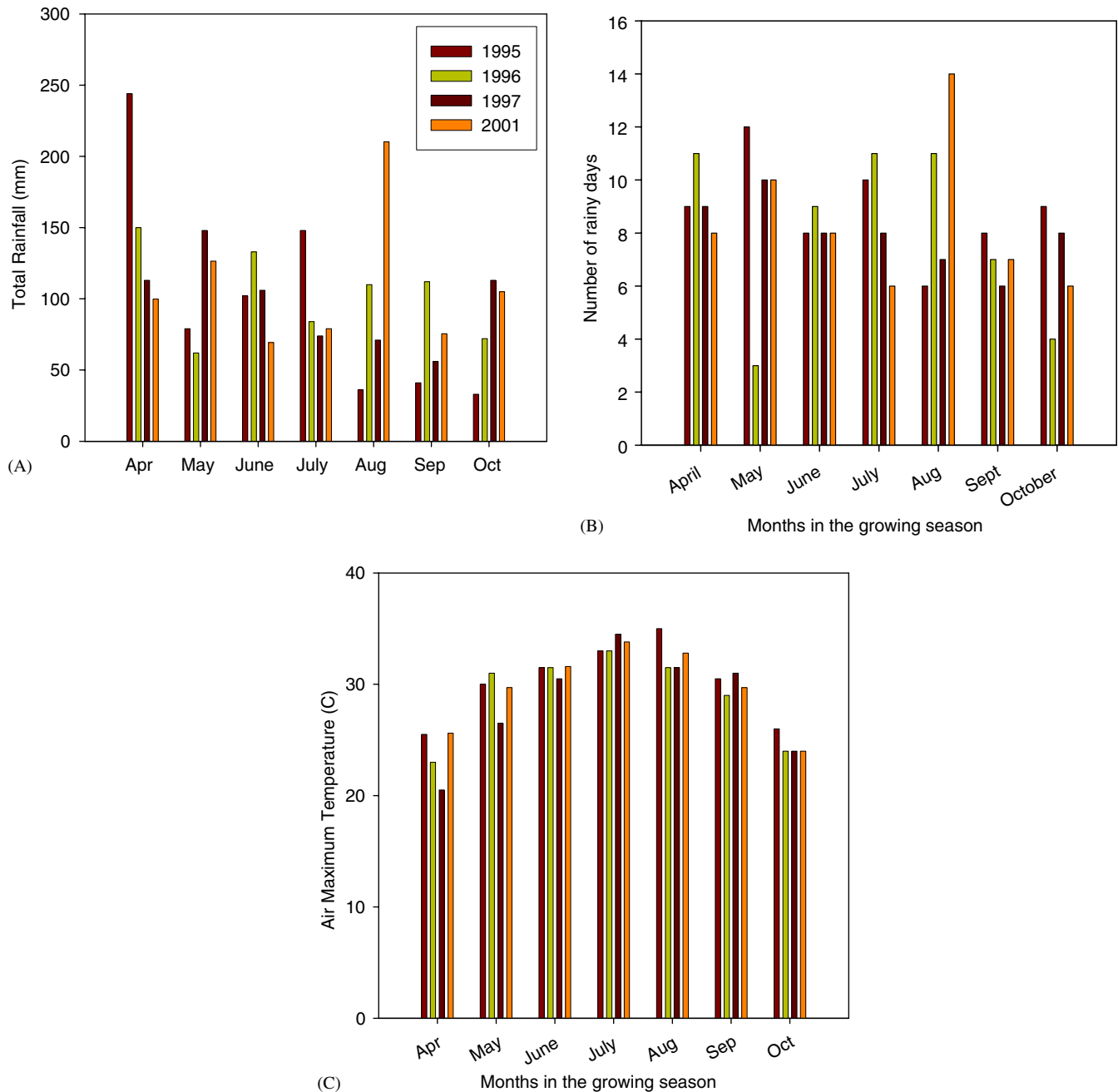


Fig. 1. (A–C) Total rainfall, number of rainy days and average air temperatures for the months of April through September for 1995–1997 and 2001.

than 50% on 27 of 31 days and $\geq 60\%$ on 13 of 31 days. The number of rain days in August of 1995, 1996 and 1997 was 6, 11, and 7, respectively (Fig. 1B). The average maximum temperature was 33 °C (Fig. 1C). The average temperatures were 35 °C for 1995, and 31 °C for 1996 and 1997. The frequent rain events in August and September of 2001 (Figs. 1A and C) was associated with higher PL than in other years (Tables 2 and 6).

In 2001, seed from early planted MG IV cultivars in both irrigated and nonirrigated treatments had significantly higher incidence of PL (70%) than did seed from

irrigated and nonirrigated late-planted (46%) MG IV cultivars (Table 2). The PL for 2001 was significantly higher for early planted MG IV in both irrigated and nonirrigated (70%) treatments. Incidence of PL in late-planted MG IV cultivars was not significantly different from early or late-planted MG V cultivars in the nonirrigated treatment. There was no treatment difference in PL in 1995. There was also no difference between treatments in 1997 except for early planted and nonirrigated MG V cultivars (7%). However, in 1996, early planted, irrigated (19%) and nonirrigated (20%)

Table 2

The percentage incidence of PL (*Phomopsis longicolla*), SHR (seed health rating) and GERM(germination) for DOP (date of planting, E = early, L = late), irrigated (I) and nonirrigated (NI), and maturity group (MG) in 1995, 1996, 1997, and 2001 at Stoneville, MS

Year	DOP	Irrigation	MG	PL (%)	FLSD ^a	SHR (%)	FLSD ^a	GERM	
1995	E	I	MG IV	5	cdefgh	17	efg ^b	65	bcdef ^c
1995	E	NI	MG IV	0.9	Fgh	7	g	77	bcdef
1995	L	I	MG IV	10.1	cdefgh	16	bcde	78	abcdef
1995	L	NI	MG IV	0.3	Gh	2	e	63	cdef
1995	E	I	MG V	0.8	Gh	2	g	81	bcde
1995	E	NI	MG V	0.6	Gh	10	fg	68	bcdef
1995	L	I	MG V	0.04	Gh	1	e	98	a
1995	L	NI	MG V	0.6	Gh	4	e	73.9	bcdef
1996	E	I	MG IV	18.9	cdef	54	bd	49.5	fhi
1996	E	NI	MG IV	20.3	Ce	68	ac	30.9	gj
1996	L	I	MG IV	10.1	cdefgh	35	bc	80	abcde
1996	L	NI	MG IV	9.9	dfghi	36	b	66.2	cdef
1996	E	I	MG V	4.7	dfghi	11	fg	91.5	abc
1996	E	NI	MG V	5.5	cdefgh	9	fg	92.4	abc
1996	L	I	MG V	2.1	dfghi	8	cde	93.8	abc
1996	L	NI	MG V	2.8	dfghi	4	de	96.7	ab
1997	E	I	MG IV	5.1	cdefgh	25	efg	78.1	bcef
1997	E	NI	MG IV	4.9	cdefgh	35	def	56.6	dgh
1997	L	I	MG IV	6.7	cdefgh	20	bcde	84.3	abc
1997	L	NI	MG IV	2.8	Fgh	18	bcde	79	bce
1997	E	I	MG V	5.4	cdefgh	21	efg	81.3	bcd
1997	E	NI	MG V	0	H	11	fg	86.2	abc
1997	L	I	MG V	7.3	cdefg	28	bcd	75.6	bcde
1997	L	NI	MG V	1.4	Gh	28	bcd	72.2	bcdef
2001	E	I	MG IV	70.3	A	83	ab	16.8	ij
2001	E	NI	MG IV	69.5	A	80	ab	22	ij
2001	L	I	MG IV	45.6	B	84	a	16.1	j
2001	L	NI	MG IV	44.3	B	85	a	13.8	j
2001	E	I	MG V	22.4	Cd	42	cde	62.9	bcdefg
2001	E	NI	MG V	50.6	B	52	cd	51.4	egh
2001	L	I	MG V	4.1	efghi	25	bcde	79.5	abcdf
2001	L	NI	MG V	43.1	B	26	bcde	80.5	abcdf

Data are means of four replicates.

^{a-c}In each column, are letters for grouping fisher's least significant differences for PL, SHR, and germination, respectively. Letters in each column followed by the same letter are not significantly different at $P < 0.05$.

had higher PL than all the other treatments. The year 1996 had the second highest incidence of PL (20%) after 2001 for early planted and nonirrigated MG IV cultivars compared to MG V cultivars (2–5%).

The SHR for 2001 was also higher for early and late-planted, irrigated and nonirrigated treatments of MG IV and ranged between 80% and 85%. In 1996, SHR was higher for MG IV (35–68%) compared to MG V cultivars (4–11%). The SHR for 1995 and 1997 was lower (1–35%) and germination was higher (57–98%) than for 1996 and 2001. 2001 had lower seed germination for early and late-planted irrigated and nonirrigated MG IV (14–22%) (Table 2) compared to early and late-planted, irrigated and nonirrigated MG V (51–81%). Late-planted irrigated and nonirrigated MG V cultivars had the highest seed germination (80–81%) and the lowest SHR (25–26%) in the 2001 test. Germination for early and late planted MG V was generally higher in all

four years than in the same plantings in MG IV cultivars.

Analysis of the test of fixed effects for PL (Table 3), SHR (Table 4), and germination (Table 5) indicated that there was a significant interaction due to year, MG, irrigation, and DOP. The main effects across all variables (Table 6) indicate that PL was significantly higher in 2001 (44%), followed by 1996 (9%), 1997 (4%), and 1995 (2%). The highest seed germination of 77% was in 1995 and 1997 and the lowest was (43%) in 2001. The lowest SHR was in 1995 (7%), and the highest was in 2001 (60%). When planting date, irrigation, and MGs were each compared across all variables (Table 6), early planting had significantly higher PL (17%) than late planting (12%), irrigated treatment had higher PL (16%) than nonirrigated (13%) and MG IV cultivars had higher PL (20%) than MG V cultivars (9%). Germination was lower for early planting (63%) than

Table 3

Tests of fixed effects of *P. longicolla* for (YR), date of planting (DOP), irrigation (IRR) and maturity group (MG) for 1995–1997 and 2001 at Stoneville, MS

Effect	DF	F-value	P>F
Year	3	14.81	0.0002
Date of planting (DOP)	1	9.91	0.0027
Irrigation (IRR)	1	4.28	0.0415
DOP*IRR	1	0	0.9746
Year*DOP	3	20.28	<0.0001
Year*IRR	3	21.07	<0.0001
Year*DOP*IRR	3	0.73	0.5392
Maturity group (MG)	1	9.71	0.0029
DOP*MG	1	1.88	0.1743
IRR*MG	1	17.06	<0.0001
DOP*IRR*MG	1	1.56	0.2141
Year*DOP*IRR*MG	12	5.96	<0.0001

Table 4

Tests of fixed effects of seed health rating (SHR) for years (YR), date of planting (DOP), irrigation (IRR) and maturity group (MG) for 1995–1997 and 2001 at Stoneville, MS

Effect	DF	F-value	Pr>F
YR	3	12.01	<0.0001
DOP	1	5.85	0.0208
IRR	1	0.14	0.7167
DOP*IRR	1	0.55	0.4695
YR*DOP	3	1.42	0.2633
YR*IRR	3	0.84	0.4953
YR*DOP*IRR	3	0.08	0.9711
MG	1	18.45	<0.0001
DOP*MG	1	0.74	0.3951
IRR*MG	1	0.39	0.5395
DOP*IRR*MG	1	0.47	0.5017
YR*DOP*IRR*MG	12	3.23	0.0147

Table 5

Tests of fixed effects of germination for years (YR), date of planting (DOP), irrigation (IRR) and maturity group (MG) for 1995–1997 and 2001 at Stoneville, MS

Effect	DF	F-value	Pr>F
YR	3	5.27	0.0653
DOP	1	7.01	0.0181
IRR	1	8.56	0.0049
DOP*IRR	1	0.68	0.415
YR*DOP	3	0.84	0.4886
YR*IRR	3	0.66	0.5821
YR*DOP*IRR	3	1.18	0.3267
MG	1	20.1	<0.0001
DOP*MG	1	0.13	0.7217
IRR*MG	1	0	0.9667
DOP*IRR*MG	1	0.02	0.9024
YR*DOP*IRR*MG	12	3.55	0.0003

late plantings (73%), higher for irrigated (72%) than for nonirrigated (64%) and higher for MG V (81%) than for MG IV (55%). SHR was higher for early planting

Table 6

Mean percent of *P. longicolla* (PL), seed health rating (SHR) and germination as influenced by the main effects of date of planting (DOP), Maturity group (MG), and irrigation and years (1995–1997 and 2001) at Stoneville, MS

Main effects	Per cent ^a		
	PL	SHR	Germination
<i>DOP</i>			
E	17 a	33 a	63 b
L	12 b	26 b	73 a
<i>Irrigation</i>			
I	16 a	29 a	72 a
NI	13 b	30 a	64 b
<i>Maturity group</i>			
IV	20 a	42 a	81 a
V	9 b	18 b	55 b
<i>Year</i>			
1995	2 b	7 c	77 a
1996	9 b	28 b	75 a
1997	4 b	23 b	77 a
2001	44 a	60 a	43 b

Data are means across treatments for each main effect.

^aLetters in each column followed by the same letter are not significantly different at $P<0.05$.

(33%) than late planting (26%) and higher for MG IV (42%) than for MG V (18%). There was no difference for SHR between irrigated (29%) and nonirrigated (30%) treatments.

Pearson correlation coefficients indicated that there was a negative correlation ($P\leq 0.01$) between seed germination and PL with $r = -0.77, -0.97, -0.87$, for 1995, 1996, and 2001, respectively (Table 7). There was also a significant positive correlation between PL and SHR ($r = 0.97$ and 0.87 for 1996 and 2001, respectively). This significant correlation between PL and SHR indicates that SHR could be an indirect measure of PL. Germination and SHR also had a significant negative correlation in 1996 ($r = -0.98$) and 2001 ($r = -0.997$).

4. Discussion

In August of 2001, the weather just prior to the R8 stage appeared to have a significant influence on the incidence of PL. The average air temperatures during August 1996 and 2001 were 31.5 and 33 °C, respectively, and rainfall frequency was much higher in 1996 and 2001 than in 1995 and 1997. This suggests that 1996 and 2001 had a more favourable environment with higher moisture availability than in 1995 and 1997. A high humidity and high temperature combination was a factor in seeds with the most PL infection and poorest

Table 7

Pearson correlation coefficients between PL (*Phomopsis longicolla*), SHR (Seed Health Rating) and germination (GERM) for 1995, 1996, 1997 and 2001

	1995		1996		1997		2001	
	SHR	GERM	SHR	GERM	SHR	GERM	SHR	GERM
PL	0.1	−0.77	0.97	−0.97	0.1	−0.48	0.87	−87
	0.67	0.02	<0.0001	<0.0001	0.81	0.23	<0.0001	<0.0001
SHR		−58		−0.98		−0.86		−0.997
		0.12		<0.0001		0.007		<0.0001

seed germination in 2001. There were 8, 7, 6, and 7 days of rain in September 1995, 1996, 1997, and 2001, respectively, and maximum average air temperature was $\geq 31^{\circ}\text{C}$ for all years. The total rainfall for September was 41, 110, 55, and 76 mm for 1995, 1996, 1997, and 2001, respectively, indicating conditions were also good for continued infection by PL in 1996 and 2001.

There were some differences in PL between irrigated and nonirrigated treatments in 1995 and 1997, suggesting that the effect of irrigation on PL as well as SHR and germination may be measured under less rainfall. Even though the level of PL was reduced in drier years, irrigated treatments still produced a higher level of PL than nonirrigated treatments, suggesting the importance of moisture on the incidence of PL. Germination increased and PL and SHR were reduced during drier years. However, lower yields can also be expected under these conditions. Date of planting may have a significant influence only under PL-conducive environments like 2001.

The extremely rainy August and the small effect of nonirrigated treatments prior to and during the R8 growth stage in 2001 suggests that rainfall amount and frequency have significant influence in increasing the level of PL and SHR and reducing seed germination. As such, early planting of MG IV cultivars resulted in a higher level of PL and SHR and lower germination. The low germination, however, may be overcome with later planting of MG V, although lower yield can be expected. A significant apparent difference between MG IV and V in 2001 was detected in SHR and germination. This indicates that these two rating systems may be used in concert when evaluating the effect of PL on seed quality.

The negative relationship ($P \leq 0.05$) between PL and seed germination indicates the importance of PL in the ESPS. Poor seed germination was associated with infection of PL and SHR. We feel that the quality of harvested soybean seed is variable from year to year depending on DOP, MG, and environmental conditions prior to and immediately following R8. Conducive moisture environment overrode the effect of irrigation.

Soybean seed quality should therefore be assessed on a yearly basis rather than from pooled data of multiple years.

Quality of harvested seed is of paramount importance to soybean growers and the seed industry. The incidence of PL recovered from seed, SHR, and germination are the critical measurements that are related to seed quality. This research highlights not only the importance and significance of PL, but also the importance of using the SHR and germination that in combination may provide a better measure of seed quality in assessing the effects of DOP, irrigation, and MG in ESPS plantings.

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